CIVIL ENGINEERING DIVISION
UNITED STATES COAST GUARD
WASHINGTON, D.C.

MARCH 1992

SPECIFICATION FOR COLORED ELASTOMERIC FILMS

SPECIFICATION NO. G-ECV-473

1. SCOPE

1.1 Purpose. This specification establishes the requirements for colored, elastomeric films for use as sign face materials on aids to navigation of the United States. This specification will be a qualification specification for qualifying manufacturers to be placed on a Coast Guard Qualified Products List (QPL) and a quality conformance specification for the procurement of items from manufacturers listed on the QPL.

1.2 Deliverables. Colored elastomeric films of the following descriptions, and manufacturer's instruction booklets, shall be supplied in the quantities as specified in procurement documents:

Adhesive: Heat-activated adhesive backing;

Colors: Red-orange; and
Green;

Roll Size: 24 inches x 50 yards;
36 inches x 50 yards; and
48 inches x 50 yards.

1.3 Precedence. Any ambiguity or conflict between this specification, drawings, and applicable documents shall be resolved by using the following precedence:

a. The basic contract, and its associated amendments and modifications;
b. This specification;
c. Drawings;
d. Applicable documents.

1.4 Qualification. With respect to products requiring qualification, awards will be made only for such products as have, at the time of contract award, been tested and approved for inclusion in the applicable Qualified Products List, whether or not such products have actually been so listed by that date. The attention of suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification so that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. The Specification Preparing Activity (SPA), Commandant (G-ECV) U.S. Coast Guard, Washington D.C. 20593-0001, shall maintain the Qualified Products List, and information pertaining to qualification of products may be obtained from that activity.

2. APPLICABLE DOCUMENTS.

2.1 Applicability. The following documents form a part of this specification to the extent specified herein:

2.1.1 Military Standards.

MIL-STD-105E 10 May 89	Sampling Procedures and Tables for Inspection by Attributes.

2.1.2 Non-Government documents.

American Plywood Association: U.S. Product Standard PS 1-83 30 Dec 83	Construction & Industrial Plywood with Typical APA Grade-Trademarks.
American Society for Testing and Materials: ASTM G26-90 26 Jan 90	Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials.
American Society for Testing and Materials: ASTM D4956-90 26 Oct 90	Standard Specification for Retroreflective Sheeting for Traffic Control
International Commission on Illumination: CIE N^{o} 15.2 1986	Colorimetry, Second Ed.

2.2 Source of documents. The documents may be obtained from the following sources:

2.2.1 Government documents.

Standardization Documents Order Desk
Building 4, Section D
700 Robbins Avenue
Philadelphia, PA 19111-5094

2.2.2 Non-Government documents.

American Plywood Association
PO Box 11700
Tacoma, Washington 98411

American Society of Testing and Materials
1916 Race Street
Philadelphia, PA 19103

Mr. Thomas M. Lemons
TLA Lighting Consultants, Inc.
72 Loring Avenue
Salem, MA 01970
(For CIE N^{o} 15.2)

3. REQUIREMENTS.

3.1 General. The films are intended for application to Grade A-B marine or High Density Overlay (HDO) plywoods (PS 1-83) or to corrosion resistant aluminum sheet, such as aluminum alloy 6061-T6. To allow maximum design opportunity, no requirements will be given regarding the composition of the films or their adhesives. Rather, the performance requirements will define qualification of an acceptable product. The films shall withstand exposure to a marine environment from a colorimetric as well as a mechanical standpoint for a minimum of five years. These five years are exclusive of storage requirements. The materials shall remain in place once applied and retain their color and luminous reflectance.

3.2 Qualification. Colored, elastomeric films submitted for qualification and listing on the applicable QPL shall be in conformance with all requirements of this specification.

3.3 Standardization of design and certification. Films supplied under this specification must not differ in any way from those qualified and approved for listing on the applicable qualified products list, except for changes that have been described in detail to and approved by the SPA. Contractors must submit a certification to this effect for each lot of film furnished under this specification. In the event a contractor wishes to introduce any changes to improve the quality of a product, the SPA may require repetition of any or all of the qualification tests before the proposed changes are approved.

3.4 Environment. Film supplied under this specification shall withstand a marine environment described as:

a. Temperature range of -40^{o}F to $+140^{o}$F;
b. Humidity range from 0 to 100 percent;
c. Winds up to 100 knots;
d. Salinity extremes (salt spray);
e. Sunlight exposure up to 5000 MJ/m^2 per year;
f. Guano deposits; and
g. Mold and fungus growth.

3.5 Instructions. Full directions, in the form of a booklet, shall be furnished with each purchase placed under this specification. The booklet shall contain instructions including, but not limited to; application of the film, preparation of substrates prior to application, and storage requirements. Any special safety considerations, particularly with regard to the flammability of the film, shall be noted. The booklet shall have dimensions of 8.5 by 11 inches. The instruction booklet shall be available for purchase as a separate item.

3.6 Physical properties.

3.6.1 Appearance. The film shall be free of ragged edges, cracks, scales, pits, blisters, and dirt. The surface shall appear uniform.

3.6.2 Dimensions. Rolls of the film shall have widths within 1% of the size ordered. The roll length shall equal or exceed the length ordered.

3.6.3 Thickness. The film thickness without the protective liner shall not exceed 0.020 inches.

3.6.4 Flexibility. The film shall not crack or delaminate when handled and applied to smooth surfaces at $70^{o}F \pm 10^{o}F$.

3.6.5 Adhesive. The adhesive shall permit application without additional adhesive coats on either the film or the surface to which the film is applied. It shall be a tack-free adhesive activated by applying heat, in the range of $180^{o}F$ to $190^{o}F$, to the film; as in the heat-vacuum process used in sign fabrication. The film shall be sufficiently tack-free up to $100^{o}F$ so it can be positioned without damaging the film.

3.6.6 Liner. A protective liner shall cover the adhesive backing. The liner shall be removable in one piece, without requiring water or other solvents. During removal the liner shall not break, shall not tear, and shall not delaminate any of the adhesive from the film.

3.6.7 Ability to be cut. The film shall be capable of being cut with a sharp instrument such as a utility knife (replaceable blade type) or scissors. The cut edge shall be free of tears, chips, or cracks.

3.7 Performance properties.

3.7.1 Adhesion. Films applied in accordance with the manufacturer's instructions shall not come loose, lift, peel or bubble when exposed to the marine environment for five years.

3.7.2 Shrinkage. With the liner removed, the film shall not shrink more than 0.5% in ten minutes and not more than 2.0% in 24 hours.

3.7.3 Color.

3.7.3.1 New film. The color of new film, when plotted on the CIE 1931 chromaticity diagram, shall fall within the boundaries denoted "New Film" in Table I and illustrated in Figure 1.

3.7.3.2 Color stability. Throughout a five year exposure to the marine environment, the film color, when plotted on the CIE 1931 chromaticity diagram, shall remain within the boundaries denoted "Five Years in the Marine Environment" in Table I and illustrated in Figure 1.

3.7.4 Luminous reflectance.

3.7.4.1 New film. The luminous reflectance of new film shall meet or exceed the values:

Red-orange: 18% reflectance; and
Green: 35% reflectance.

3.7.4.2 Reflectance stability. Throughout a five year exposure to the marine environment, the luminous reflectance of colored, elastomeric film shall not fall below the values:

Red-orange: 16% reflectance; and
Green: 30% reflectance.

3.8 Resistance properties.

3.8.1 Resistance to heat, cold, and humidity. Film which has been applied in conformance with the manufacturer's instructions shall not crack, peel, chip, or delaminate when exposed to the marine environment for five years.

3.8.2 Solvent resistance. Neither the film nor the adhesive shall dissolve, pucker, or blister in kerosene, turpentine, toluene, xylene or methyl alcohol.

3.8.3 Fungus Resistance. The film shall be resistant to fungus growth, with no discoloration, reduction in luminous reflectance, loss of adhesion, or degradation of surface finish due to fungus growth.

3.8.4 Storage stability. The film shall meet the requirements of this specification after being stored in a warehouse at 50^{o}F to 90^{o}F and 30 to 50 percent relative humidity for 24 months.

4. QUALITY ASSURANCE PROVISIONS.

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Qualification: 4.3 through 4.7; and
b. Production: 4.8.

4.1.1 Performance Compliance. The Coast Guard reserves the right to verify and to perform any tests on production colored, elastomeric film to verify that the film is in conformance with this specification. These tests may be different than tests called for in this specification.

4.2 Inspection responsibility.

4.2.1 Qualification inspection responsibility. Qualification inspections are the responsibility of the Contractor and will be conducted at a facility acceptable to the Government. A test plan shall be submitted to the SPA not later than 30 days prior to commencement of the qualification testing. At a minimum this plan shall include:

a. A listing of each product to be tested.
b. A chronological listing of the tests to be performed.
c. Location of the test facility.
d. Detailed test procedures for each test, including a description of any equipment to be used in a test.
e. Any additional information necessary to fully describe the qualification inspection.
f. Test data sheets shall be provided with the test plan and shall be used to record observed performance data.

4.2.2 Production inspection responsibility. The Contractor shall conform to all requirements of the Federal Acquisition Regulations (FAR) Part 52.246-1; Contractor Inspection Requirements, and Part 52.246-2; Inspection of Supplies, Fixed Price.

4.3. Qualification.

4.3.1 Qualification inspection. Upon notification to the SPA of a desire to be placed on the QPL, the Contractor shall provide to the SPA a detailed test plan of the qualification testing. After approval of the qualification test plan by the SPA, the Contractor shall notify the SPA two weeks prior to the start of testing, to confirm the dates and locations of the testing. A government representative shall monitor the tests. The qualification testing requirements are specified in Table II.

Table II
Qualification Inspections

Inspection	Requirement	Test method
Appearance	3.6.1	4.4
Dimensions	3.6.2	4.5.1
Thickness	3.6.3	4.5.2
Flexibility	3.6.4	4.5.3
Adhesive	3.6.5	4.4
Liner	3.6.6	4.4
Ability to be cut	3.6.7	4.4
Adhesion	3.7.1	4.5.4
Shrinkage	3.7.2	4.5.5
Color; new film	3.7.3.1	4.6.1
Color stability	3.7.3.2	4.6.2
Reflectance; new film	3.7.4.1	4.6.1
Reflectance stability	3.7.4.2	4.6.2
Resistance to heat, cold and humidity	3.8.1	4.7.1
Solvent resistance	3.8.2	4.7.2
Fungus resistance	3.8.3	4.7.3

4.3.1.1 Qualification inspection records. The Contractor shall maintain records, including the test plan and completed test data sheets, of the qualification inspection. Upon completion of the inspection, the contractor shall submit to the SPA a test report documenting, at a minimum, test equipment used, last date of calibration of test equipment, and completed test data sheets.

4.3.2 Qualification inspection submission. Samples of film submitted for qualification shall be representative of the proposed normal production. These samples shall be continuous rolls 12 inches in width and 50 yards in length. One roll shall be submitted for each color the Contractor wishes to qualify.

4.3.3 Test conditions. Unless otherwise specified tests shall be conducted at room temperature and humidity, herein defined as $70^{o}F \pm 10^{o}F$ and 30 to 50 per cent relative humidity.

4.3.4 Test panels. When tests are to be performed using test panels, samples of the film(s) shall be applied according to the manufacturer's instructions to 1/2 inch or 3/8 inch marine plywood or HDO plywood, and to 1/8 inch aluminum or aluminum alloy sheet.

4.4 Visual inspection. The film shall be inspected for compliance with Table III. The entire roll of each sample shall be inspected.

4.4.1 Acceptance/rejection criteria. One defect, as defined in Table III, shall constitute failure of the whole qualification procedure for that particular product.

Table III
Visual Inspection Criteria

Inspect	Defect
Adhesive backing	Backing not completely and evenly covered with adhesive. Note: inspect whenever the liner is removed for any tests.
Liner	Missing. Does not completely cover back of sheeting. Liner breaks or tears, or removes any adhesive from the film. Note: inspect whenever the liner is removed for any tests.
Color	Not color specified.
Appearance	Surface of film not smooth. Any tear, cut, hole, crack, pit, blister, dirt, crease, or scale. Sticky edges. Any solid lump.[1] Any spot, stain or streak more than 1 inch in longest dimension.*
Ability to be cut	Any tear, chip or crack. Note: inspect whenever the film is cut.

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4.5 Mechanical tests.

4.5.1 Dimensional test. Samples shall be inspected for defects in dimensions. The width of the sample shall be measured at three random distances from the beginning of each roll. The length of each roll shall be measured.

4.5.2 Thickness test. The liner shall be removed and the film applied to a clean, smooth strip of aluminum having a known, uniform thickness. Four micrometer readings shall be taken at random places on the film. Film thickness shall be determined by subtracting the thickness of the aluminum strip from the micrometer reading.

4.5.3 Flexibility test. Condition a 1 inch by 6 inch sample of film at room temperature and humidity for 24 hours. Remove the liner and dust the adhesive with talcum powder. Bend the film in one second around a 1/8 inch mandrel with the adhesive contacting the mandrel.

4.5.4 Adhesion test. Apply 4 inches of one end of a 1 inch by 6 inch sample of film to a test panel. After conditioning the sample for 72 hours at room temperature and humidity, suspend the panel in a horizontal position with the sample facing down. Attach a 1.75 pound weight to the free end of the sample and allow the weight to hang free at an angle of 90 degrees to the panel surface for 5 minutes. At the end of the 5 minute period, check the distance of peeling. If the distance is 2.0 inches or more, the sample fails. This test shall be conducted using both types of plywood test panels, and an aluminum test panel.

4.5.5 Shrinkage test. Remove the liner from a 12 inch by 12 inch sample and place the sample on a flat surface with the adhesive side up. Measure the length and width of the sample after a 10 minute stand at room temperature and after a 24 hour stand at room temperature.

4.5.6 Acceptance/rejection criteria. Any sample failing to conform to requirements 3.6.2, 3.6.3, 3.6.4, 3.7.1, and 3.7.2 at the conclusion of mechanical testing shall constitute a failure of the whole qualification procedure for that particular product. Successful completion of the adhesion test (4.5.4) is considered adequate evidence that requirement 3.7.1 is met.

4.6 Color and luminous reflectance.

4.6.1 Test procedure. The control and weathered samples, prepared in accordance with 4.6.2, shall be tested to insure compliance with Table I. The chromaticity coordinates and luminous reflectance shall be determined using a $45^{o}/0^{o}$ or a $0^{o}/45^{o}$ geometry colorimeter. The illuminant for color and luminous reflectance measurements shall be the CIE Illuminant D_{65} (CIE N^{o} 15.2). This requirement is described in Appendix A.

4.6.2 Color and luminous reflectance stability. Four samples of each product submitted for qualification shall be applied to aluminum test panels. One sample shall be retained as a control. The remaining three samples shall be subjected to 1200 hours of accelerated exposure, as specified by Test Method A of ASTM G-26, using borosilicate inner and outer filters, and with a spectral irradiance of 0.36 W/m^2 at 340 nm. Upon completion of the accelerated exposure, the chromaticity coordinates and luminous reflectance of the samples shall be measured as specified in 4.6.1. Certified data from natural weathering testing, which indicates that the product has a color and luminous reflectance stability as specified in 3.7.3.2 and 3.7.4.2, respectively, may be presented to the SPA for consideration as fulfillment of this requirement. The decision of the SPA as to the acceptance of data from natural weathering testing shall be final.

4.6.3 Acceptance/rejection criteria. Failure of any sample to conform to requirements 3.7.3.1 and 3.7.3.2, for color and color stability, and to requirements 3.7.4.1 and 3.7.4.2, for luminous reflectance and luminous reflectance stability, shall constitute a failure of the whole qualification procedure for that particular product. A product whose chromaticity coordinates remain within the boundaries denoted "Five Years in the Marine Environment" of Table I shall be considered to have successfully demonstrated conformance to requirements 3.7.3.2 and 3.7.4.2.

4.7 Environmental tests.

4.7.1 Resistance to heat, cold, and humidity. Determine resistance to heat, cold, and humidity by the procedures in 4.7.1.1, 4.7.1.2, and 4.7.1.3 and the acceptance/rejection criteria of 4.7.4. Apply three each 12 inch by 12 inch samples to plywood and aluminum test panels. Use one sample on each type of test panel for the resistance to heat test, another sample for the resistance to cold test, and the last sample for the resistance to humidity test.

4.7.1.1 Resistance to heat. Heat one sample in an oven at 140°F ± 5°F for 24 hours. Allow the sample to cool to room temperature. Visually inspect the sample.

4.7.1.2 Resistance to cold. Expose one sample to an air temperature of -40°F ± 5°F for 24 hours. Allow the sample to warm to room temperature. Visually inspect the sample.

4.7.1.3 Resistance to humidity. Subject one sample to 100 percent relative humidity and a temperature of 75°F to 80°F for 24 hours. Remove the panel from the humidity chamber. Allow the panel to dry at room temperature. Visually inspect the sample.

4.7.2 Solvent resistance. Determine the resistance of the film to the solvents listed below by sequentially immersing a 1 inch by 6 inch sample in glass containers holding the individual solvents. Solvents and immersion times shall be as follows:

Solvent	Immersion Time
Kerosene	10 minutes
Turpentine	10 "
Toluene	1 "
Xylene	1 "
Methyl alcohol	1 "

At the end of each immersion period, remove the test panels from the containers and allow to dry before visual inspection.

4.7.3 Fungus resistance. Test procedures shall conform to Supplementary Requirement S1 of ASTM D4956, except subsection S1.3.3, line 7 shall read: "...between 37.4 to 50°F (3 to 10°C)." This requirement is found in Appendix B.

4.7.4 Acceptance/rejection criteria. A sample showing any evidence of cracking, peeling, chipping, blistering, delamination, or dissolving of the film or adhesive at the conclusion of the environmental tests shall constitute a failure of the whole qualification procedure for that particular product. Successful completion of the solvent resistance test is considered adequate evidence that requirement 3.4(f) is met. Successful completion of the fungus resistance test is considered adequate evidence that requirement 3.4(g) is met.

4.8 Production.

4.8.1 Responsibility for inspection. The Contractor shall be responsible for all production inspections. The Contractor shall provide space, personnel and test equipment for conducting all inspection requirements. All testing and inspection shall be performed at the manufacturing plant, or at other facilities acceptable to the Coast Guard. The Coast Guard reserves the right to verify or perform any of the inspections set forth in this specification where such inspections are deemed necessary to assure that supplies and services conform to the prescribed requirements.

4.8.2 Contractor's inspection system. The Contractor shall maintain an inspection system which shall insure that each item offered to the Coast Guard for acceptance conforms to contract requirements. The inspection system shall be documented and available for review by a Coast Guard Inspector.

4.8.3 Contractor's calibration system. The Contractor shall maintain a calibration and maintenance system to control the accuracy of measurement and test equipment used in the fulfillment of this contract. The system shall include, as a minimum, prescribed calibration intervals, source of calibration and a monitoring system to insure adherence to calibration schedules. Documentation in support of this requirement shall be readily available to a Coast Guard Inspector.

4.8.4 Records. The Contractor shall maintain records of all inspections and tests. The records shall indicate the nature and number of observations made, the number and type of deficiencies found, and the corrective action taken.

4.8.5 Inspections. The inspections required by 4.8.8 are not intended to supplant any controls, examinations, inspections, or tests normally employed by Contractors to assure the quality of their product.

4.8.6 Lot/Unit. The term lot shall mean "inspection lot" and is defined as the total number of rolls manufactured in one production run. The term unit is defined as an individual roll of a lot.

4.8.7 Sampling. The inspection sample size shall be in accordance with MIL-STD-105D(2), Level S-1. The acceptable quality level (AQL) shall be 4.0.

4.8.8 Acceptance/rejection criteria. One defect as defined in Table IV shall be cause for rejection of an individual roll.

Table IV
Visual, Dimensional and Thickness Inspection

Examine	Defects
Adhesive backing	Backing not completely and evenly covered with adhesive.
Liner	Missing. Does not completely cover back of sheeting.
Color	Not color specified.
Appearance	Surface of exterior film not smooth. Any tear, cut, hole, crack, blister, dirt, crease, scale or pit. Sticky edges. Any solid lump.[2] Any spot, stain or streak more than 1 inch in its longest dimension.*
Dimension	Width less than or in excess of 1% of ordered width. Length less than 50 yards.
Thickness	Thickness greater than 0.020 inch.

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5. PREPARATION FOR DELIVERY.

5.1 Packaging. Rolls of elastomeric film, as specified in the contract or order, shall be packaged in accordance with normal commercial practice. The complete package shall protect the item against damage during shipment, handling and storage.

5.2 Packing. Rolls of elastomeric film, packaged as specified in 5.1, shall be packed in boxes that will assure acceptance by common carrier and provide protection against loss and damage during multiple shipments, handling and storage. The shipping container shall comply with the National Motor Freight Classification and Uniform Freight Classification.

5.3 Marking. Each packaging container and packing carton shall be marked with the following information:

a. Type description;
b. Quantity;
c. Stock number;
d. Contract number; and
e. Manufacturer's name and address.

Appendix A

Pending an acceptable standard for the standard illuminant D_{65}, the relative spectral irradiance distribution curve for the source which is used shall match the defined curve for the CIE Illuminate D_{65} such that the square root of the mean square deviation is less than:

15.0 over the wavelength range 300-800 nanometers; or
10.0 over the wavelength range 400-700 nanometers;

with the sample points measured at not more than 10 nanometer intervals. This is described by the function:

$$\left\{ \frac{1}{n} \left[SD_{65}(\ ) - f*S(\ ) \right]^2 \right\}^{1/2} \leq 15.0 \text{ or } 10.0 \quad \text{(Eq 1)}$$

where: n = number of sample points;
$_2$ = 800 or 700 nm;
$_1$ = 300 or 400 nm;
SD_{65} = spectral irradiance of defined illuminant;
S = spectral irradiance of source used; and
f = scaling factor.

The scaling factor (f) is defined as:

$$f = \frac{\left[SD_{65}(\ )\, S(\ ) \right]}{\left[SD_{65}(\ ) \right]^2} . \qquad \text{(Eq 2)}$$

A D_{65} light source can be simulated using a Hanovia model 901-C1, 150 watt xenon-arc lamp and a Corning No. 3966 absorption filter.

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